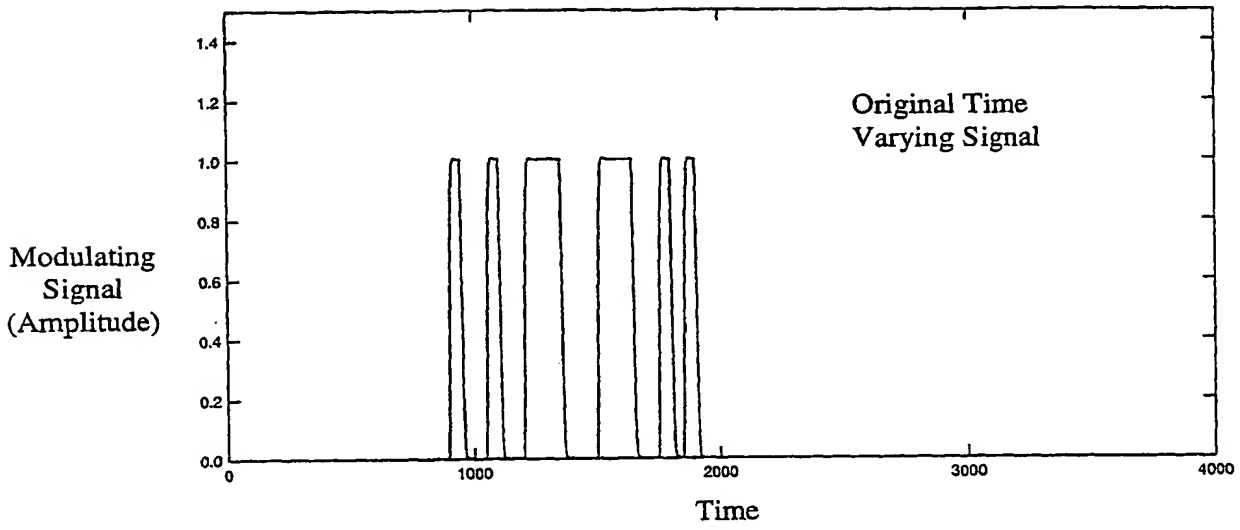

Original Time
Varying Signal
Modulating
Signal
(Amplitude)
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1000
2000
3000
4000
Time

Fig. 1

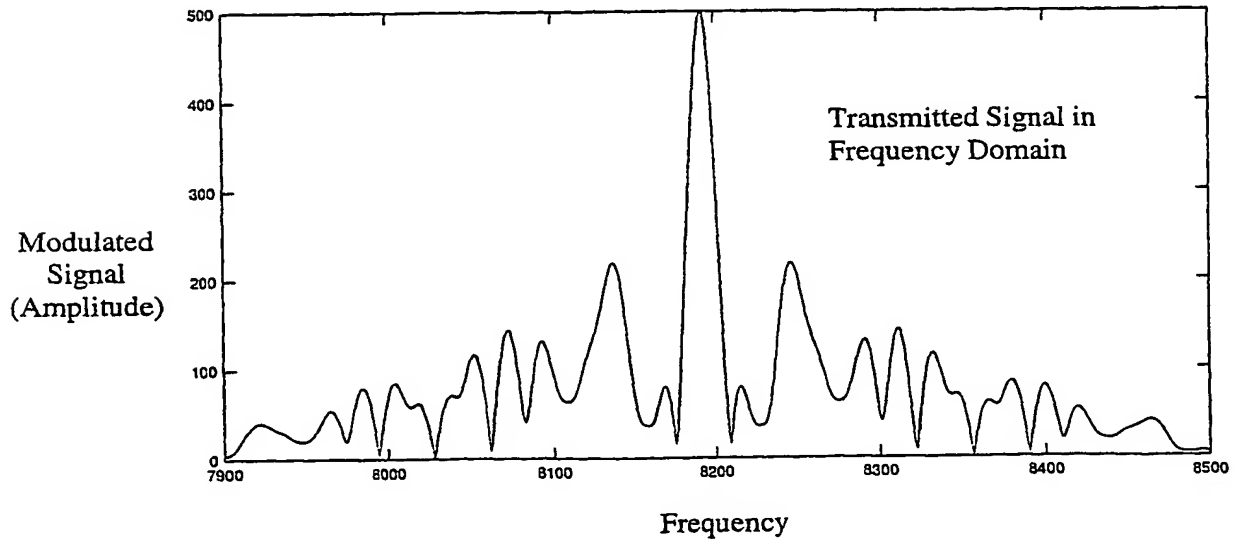

Transmitted Signal in
Frequency Domain
Modulated
Signal
(Amplitude)
500
400
300
200
100
0
7900
8000
8100
8200
8300
8400
8500
Frequency

Fig. 2

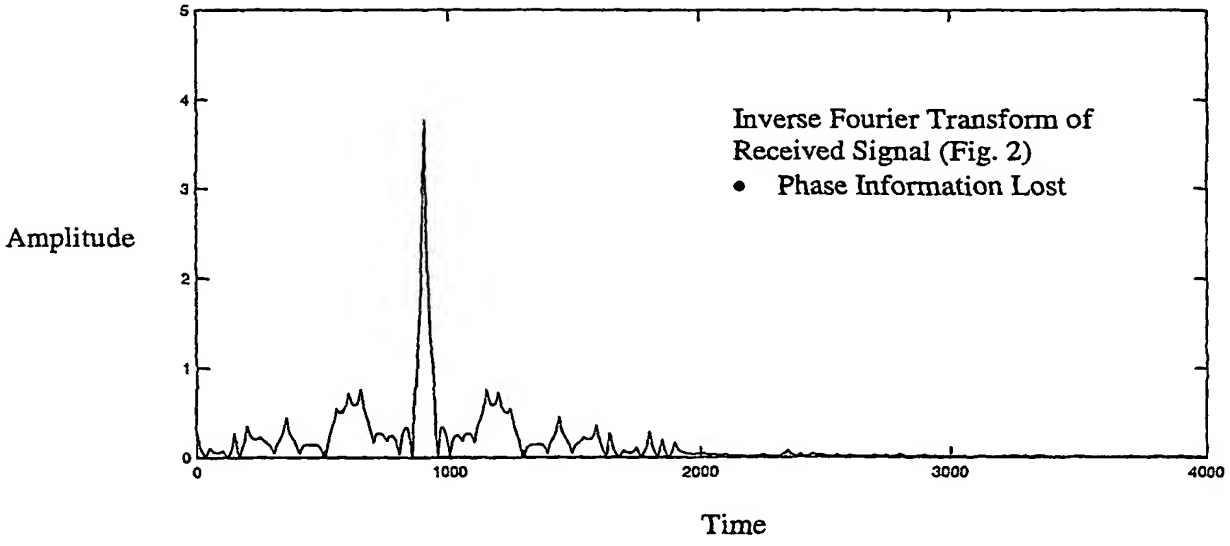

Amplitude
Inverse Fourier Transform of
Received Signal (Fig. 2)
• Phase Information Lost
0
1
2
3
4
5
0
1000
2000
3000
4000
Time

Fig. 3

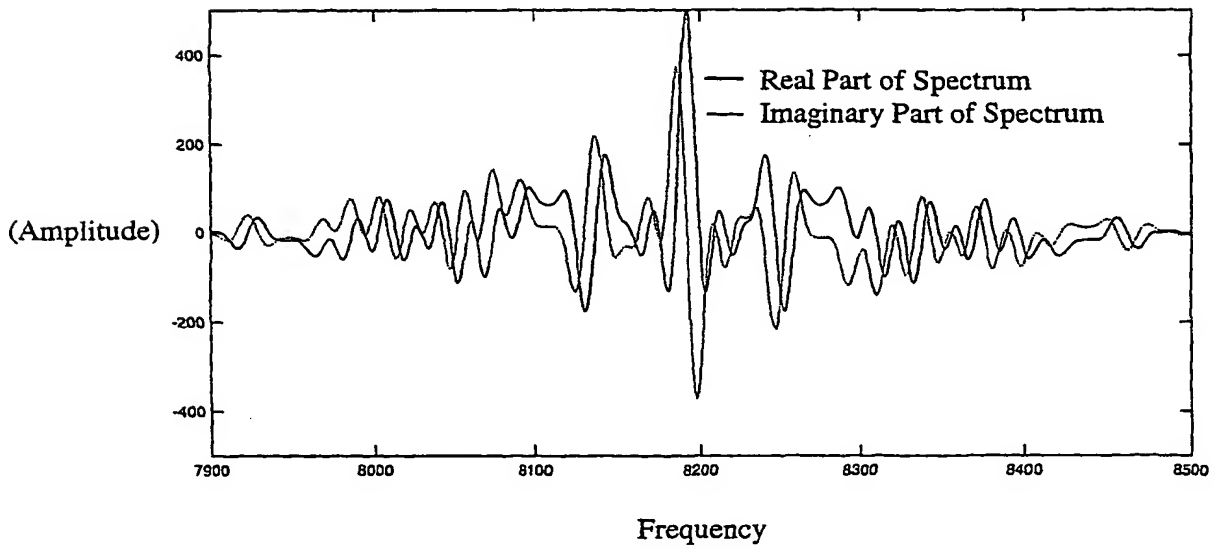

(Amplitude)
Real Part of Spectrum
Imaginary Part of Spectrum
400
200
0
-200
-400
7900
8000
8100
8200
8300
8400
8500
Frequency

Fig. 4

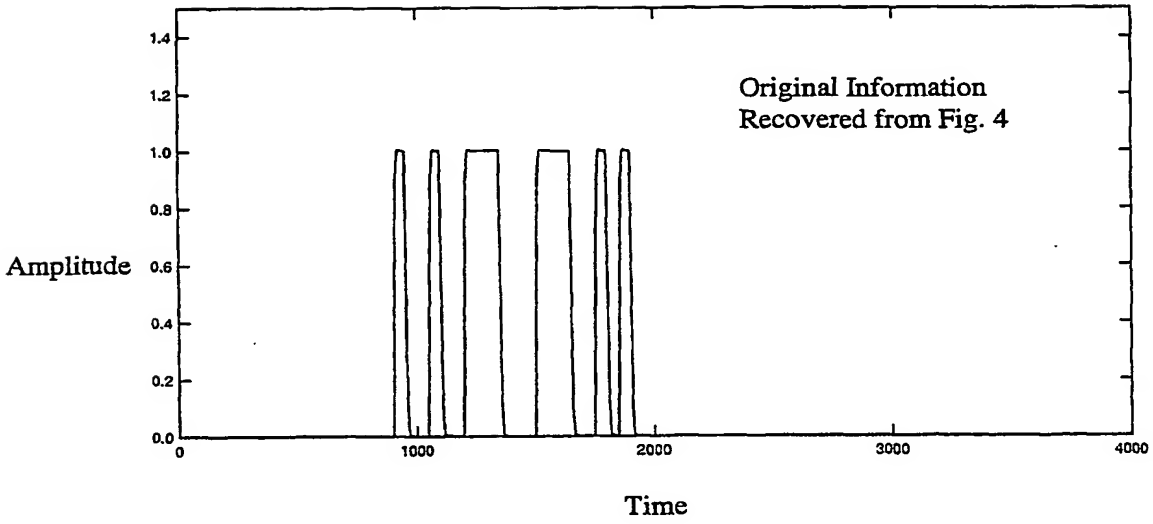

Original Information
Recovered from Fig. 4
Amplitude
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
1000
2000
3000
4000
Time

Fig. 5

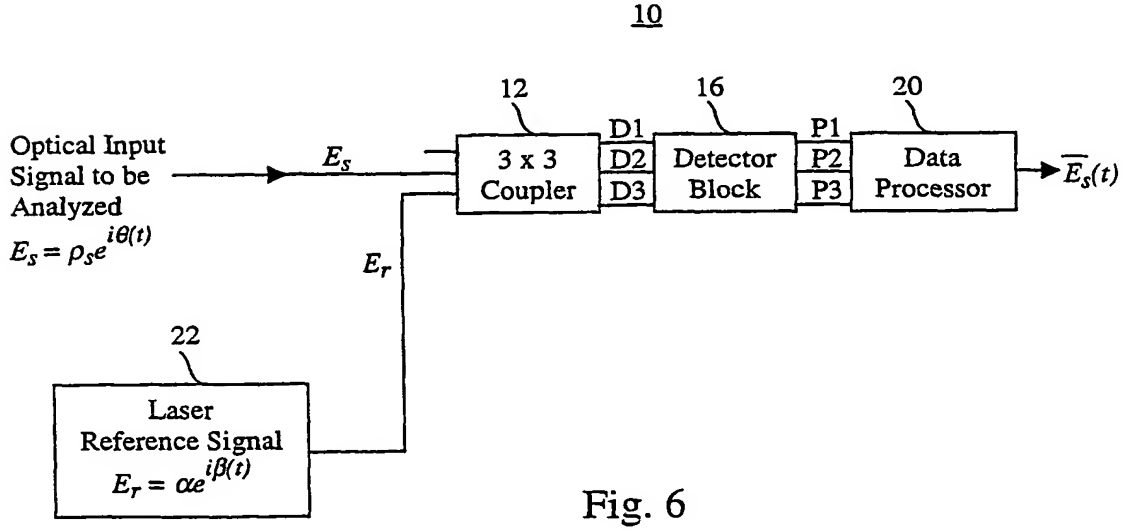

10
12
16
20
D1
D2
D3
P1
P2
P3
Optical Input
Signal to be
Analyzed
$E_S = \rho_S e^{i\theta(t)}$
E_S
3 x 3
Coupler
Detector
Block
Data
Processor
$\overline{E_S}(t)$
E_r
22
Laser
Reference Signal
$E_r = \alpha e^{i\beta(t)}$

Fig. 6

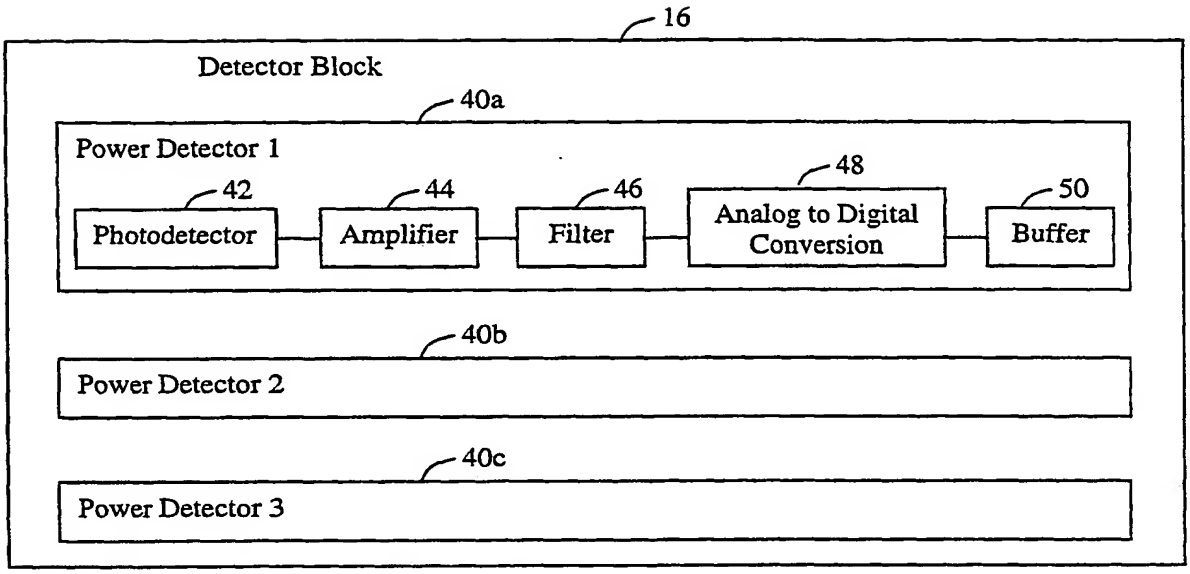

16
Detector Block
40a
Power Detector 1
42
Photodetector
44
Amplifier
46
Filter
48
Analog to Digital Conversion
50
Buffer
40b
Power Detector 2
40c
Power Detector 3

Fig. 7

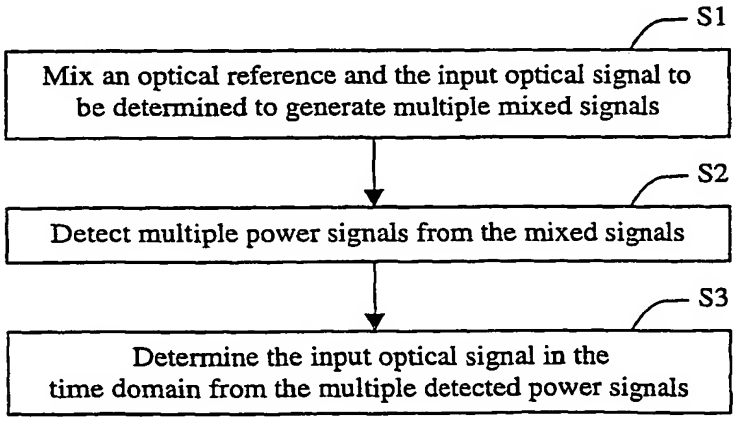

S1
Mix an optical reference and the input optical signal to be determined to generate multiple mixed signals
S2
Detect multiple power signals from the mixed signals
S3
Determine the input optical signal in the time domain from the multiple detected power signals

Fig. 8

Fig. 9A

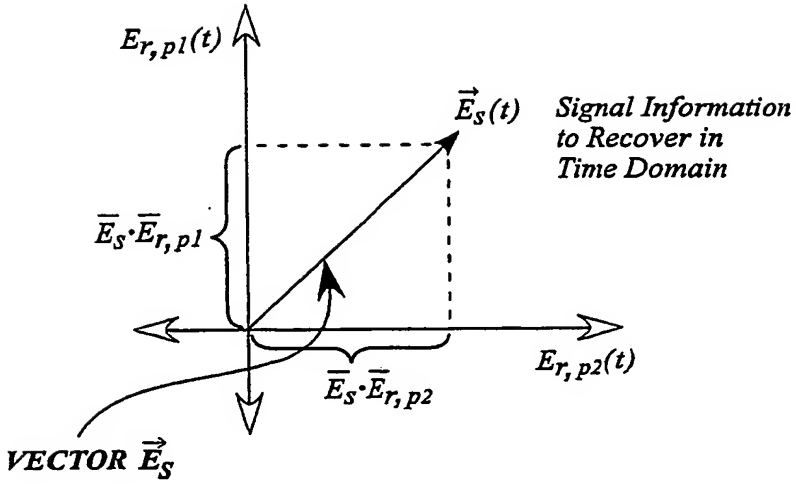


Fig. 9B

Output at Detector Block 1 $(\overline{E}_S \cdot \overline{E}_{r,p1})$

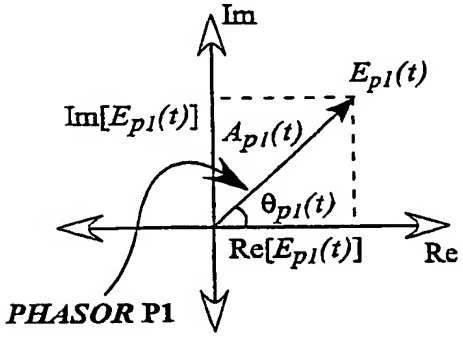
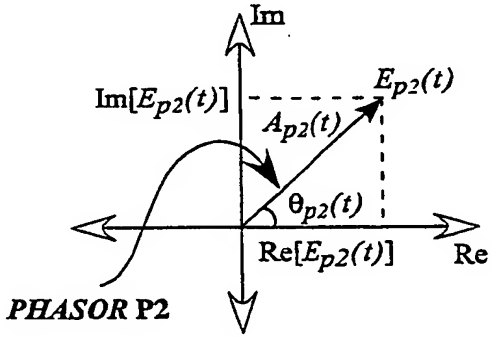


Fig. 9C

Output at Detector Block 2 $(\overline{E}_S \cdot \overline{E}_{r,p2})$



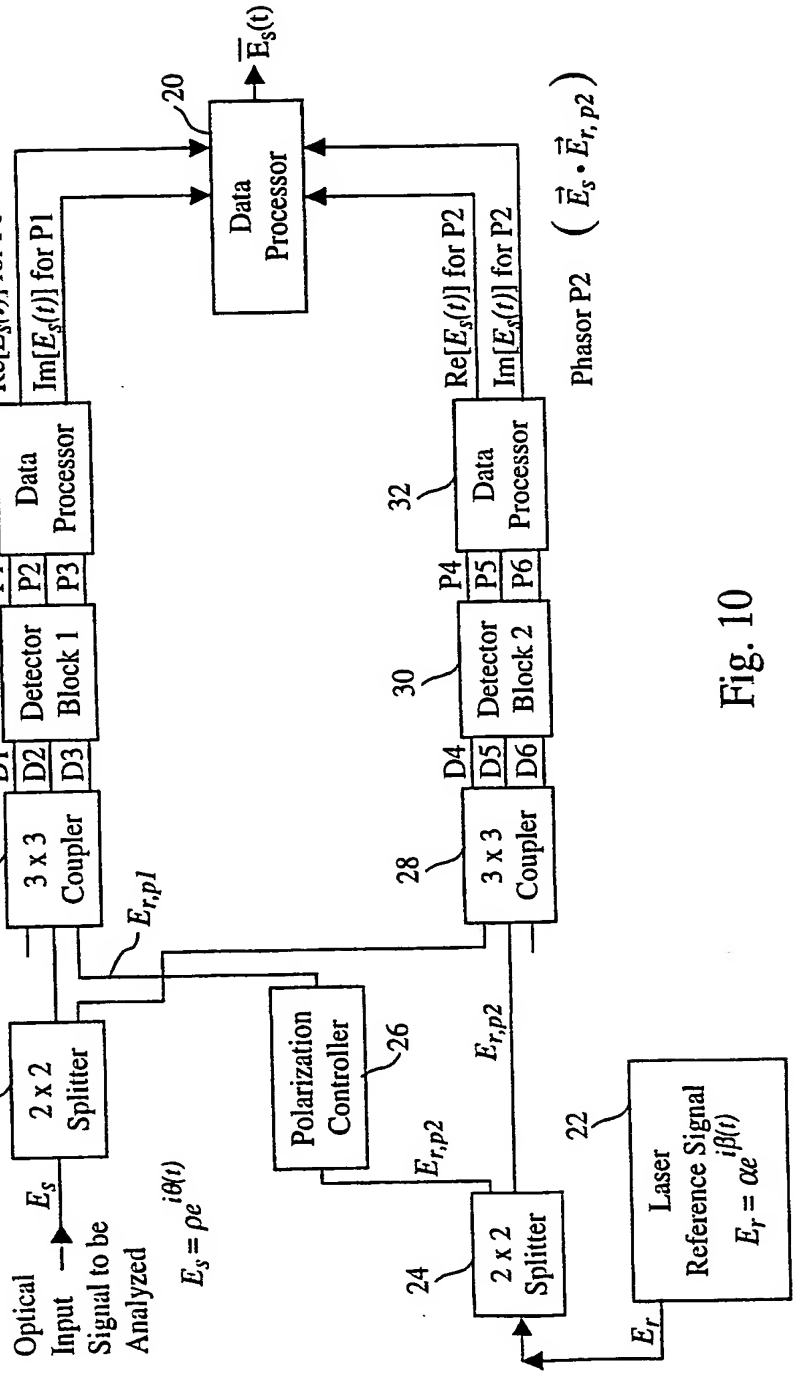

Optical Input Signal to be Analyzed
E_s
$E_s = \rho e^{i\theta(t)}$
12
2 x 2 Splitter
14
3 x 3 Coupler
D1
D2
D3
16
Detector Block 1
P1
P2
P3
18
Data Processor
Phasor P1 $(\vec{E}_s \cdot \vec{E}_{r,p1})$
Re[$E_s(t)$] for P1
Im[$E_s(t)$] for P1
$E_{r,p1}$
Polarization Controller
26
$E_{r,p2}$
24
2 x 2 Splitter
E_r
22
Laser Reference Signal
$E_r = \alpha e^{i\beta(t)}$
28
3 x 3 Coupler
D4
D5
D6
30
Detector Block 2
P4
P5
P6
32
Data Processor
Re[$E_s(t)$] for P2
Im[$E_s(t)$] for P2
Phasor P2 $(\vec{E}_s \cdot \vec{E}_{r,p2})$
20
Data Processor
$\overline{E}_s(t)$

Fig. 10

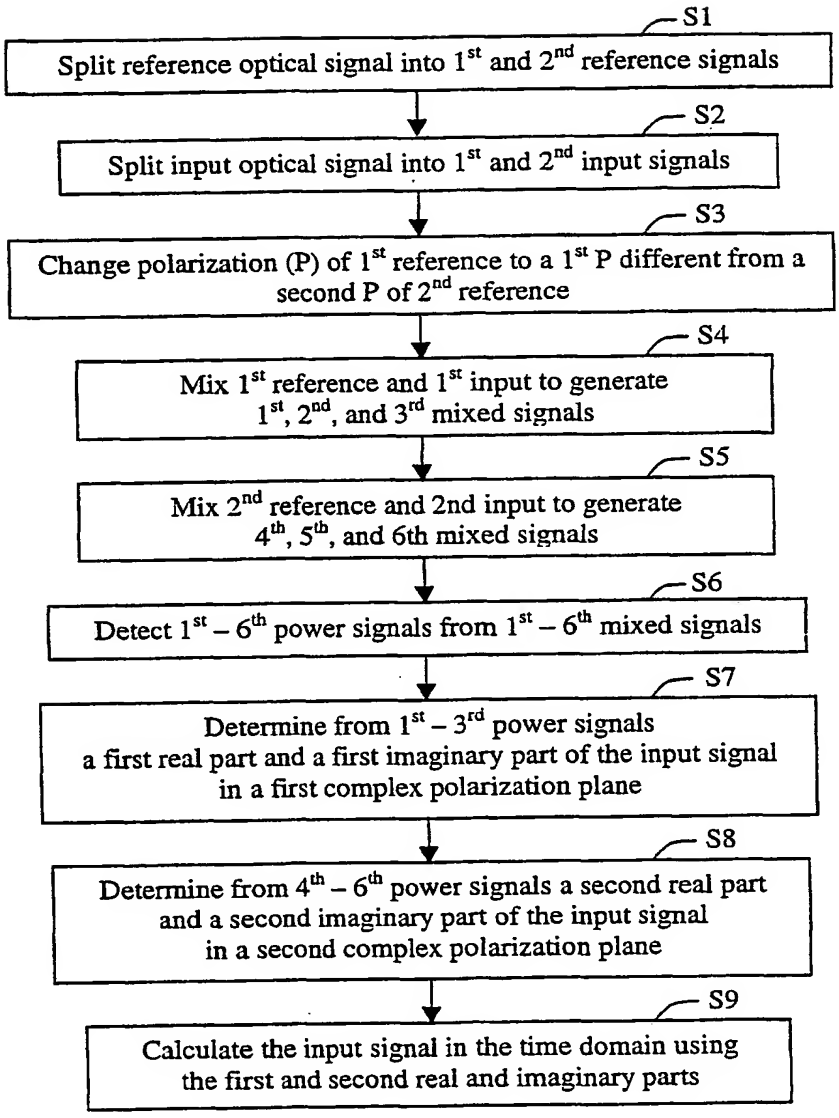

S1
Split reference optical signal into 1st and 2nd reference signals
S2
Split input optical signal into 1st and 2nd input signals
S3
Change polarization (P) of 1st reference to a 1st P different from a second P of 2nd reference
S4
Mix 1st reference and 1st input to generate 1st, 2nd, and 3rd mixed signals
S5
Mix 2nd reference and 2nd input to generate 4th, 5th, and 6th mixed signals
S6
Detect 1st – 6th power signals from 1st – 6th mixed signals
S7
Determine from 1st – 3rd power signals a first real part and a first imaginary part of the input signal in a first complex polarization plane
S8
Determine from 4th – 6th power signals a second real part and a second imaginary part of the input signal in a second complex polarization plane
S9
Calculate the input signal in the time domain using the first and second real and imaginary parts

Fig. 11

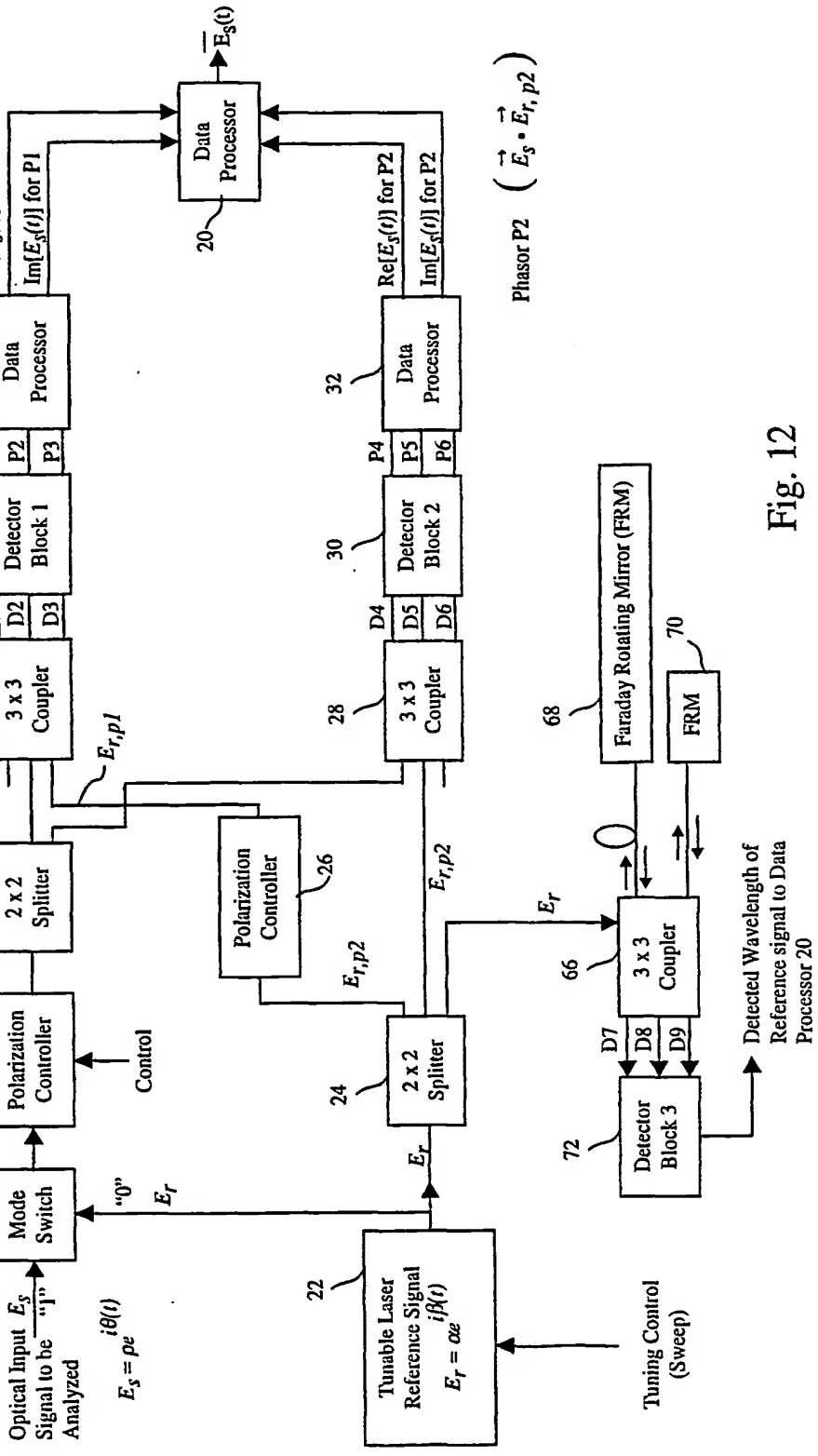

Data Processor
20
$\bar{E}_S(t)$
Phasor P1 $(\vec{E}_S \bullet \vec{E}_{r,p1})$
Phasor P2 $(\vec{E}_S \bullet \vec{E}_{r,p2})$
Re[$E_S(t)$] for P1
Im[$E_S(t)$] for P1
Re[$E_S(t)$] for P2
Im[$E_S(t)$] for P2
18
32
Data Processor
P1
P2
P3
P4
P5
P6
16
30
Detector Block 1
Detector Block 2
D1
D2
D3
D4
D5
D6
14
28
3 x 3 Coupler
$E_{r,p1}$
12
2 x 2 Splitter
Polarization Controller
26
$E_{r,p2}$
64
Polarization Controller
Control
24
2 x 2 Splitter
E_r
62
Mode Switch
"0"
"1"
Optical Input Signal to be Analyzed
E_S
$E_S = \rho e^{i\theta(t)}$
22
Tunable Laser Reference Signal
$E_r = \alpha e^{i\beta(t)}$
Tuning Control (Sweep)
68
Faraday Rotating Mirror (FRM)
70
FRM
66
3 x 3 Coupler
D7
D8
D9
72
Detector Block 3
Detected Wavelength of Reference signal to Data Processor 20

Fig. 12

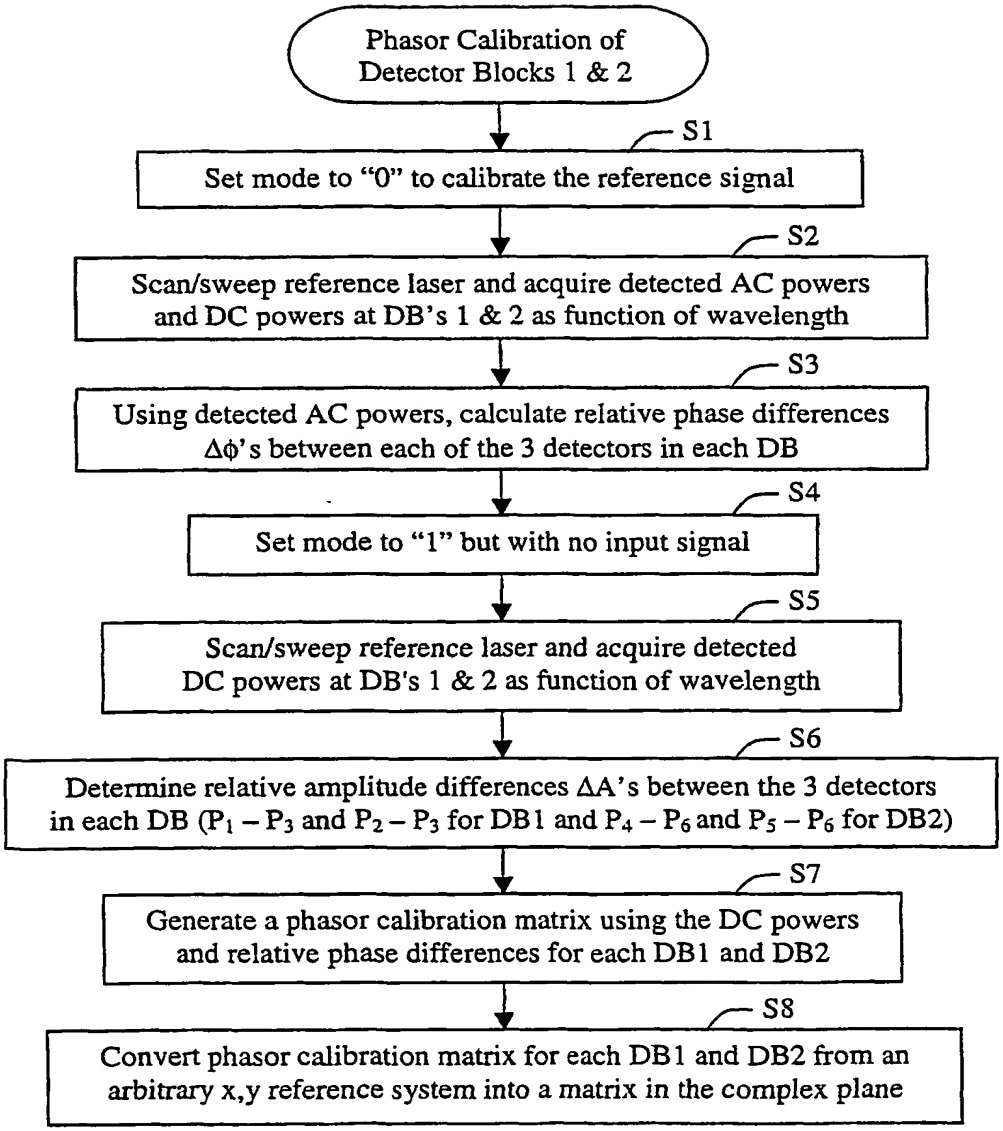

Phasor Calibration of Detector Blocks 1 & 2
S1
Set mode to "0" to calibrate the reference signal
S2
Scan/sweep reference laser and acquire detected AC powers and DC powers at DB's 1 & 2 as function of wavelength
S3
Using detected AC powers, calculate relative phase differences Δϕ's between each of the 3 detectors in each DB
S4
Set mode to "1" but with no input signal
S5
Scan/sweep reference laser and acquire detected DC powers at DB's 1 & 2 as function of wavelength
S6
Determine relative amplitude differences ΔA's between the 3 detectors in each DB ($P_1 - P_3$ and $P_2 - P_3$ for DB1 and $P_4 - P_6$ and $P_5 - P_6$ for DB2)
S7
Generate a phasor calibration matrix using the DC powers and relative phase differences for each DB1 and DB2
S8
Convert phasor calibration matrix for each DB1 and DB2 from an arbitrary x,y reference system into a matrix in the complex plane

Fig. 13

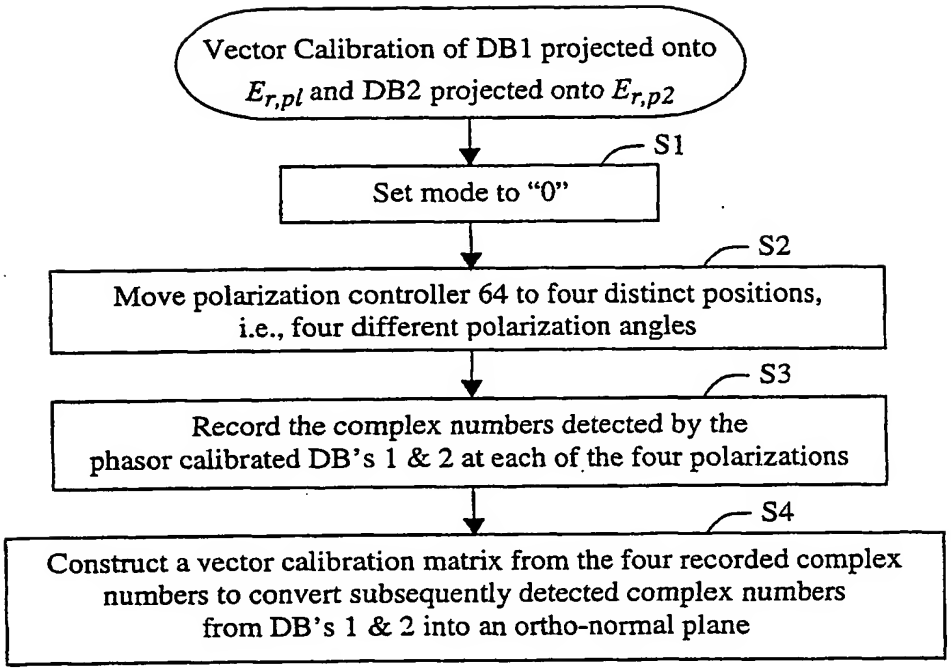

Vector Calibration of DB1 projected onto $E_{r,p1}$ and DB2 projected onto $E_{r,p2}$
S1
Set mode to "0"
S2
Move polarization controller 64 to four distinct positions, i.e., four different polarization angles
S3
Record the complex numbers detected by the phasor calibrated DB's 1 & 2 at each of the four polarizations
S4
Construct a vector calibration matrix from the four recorded complex numbers to convert subsequently detected complex numbers from DB's 1 & 2 into an ortho-normal plane

Fig. 14

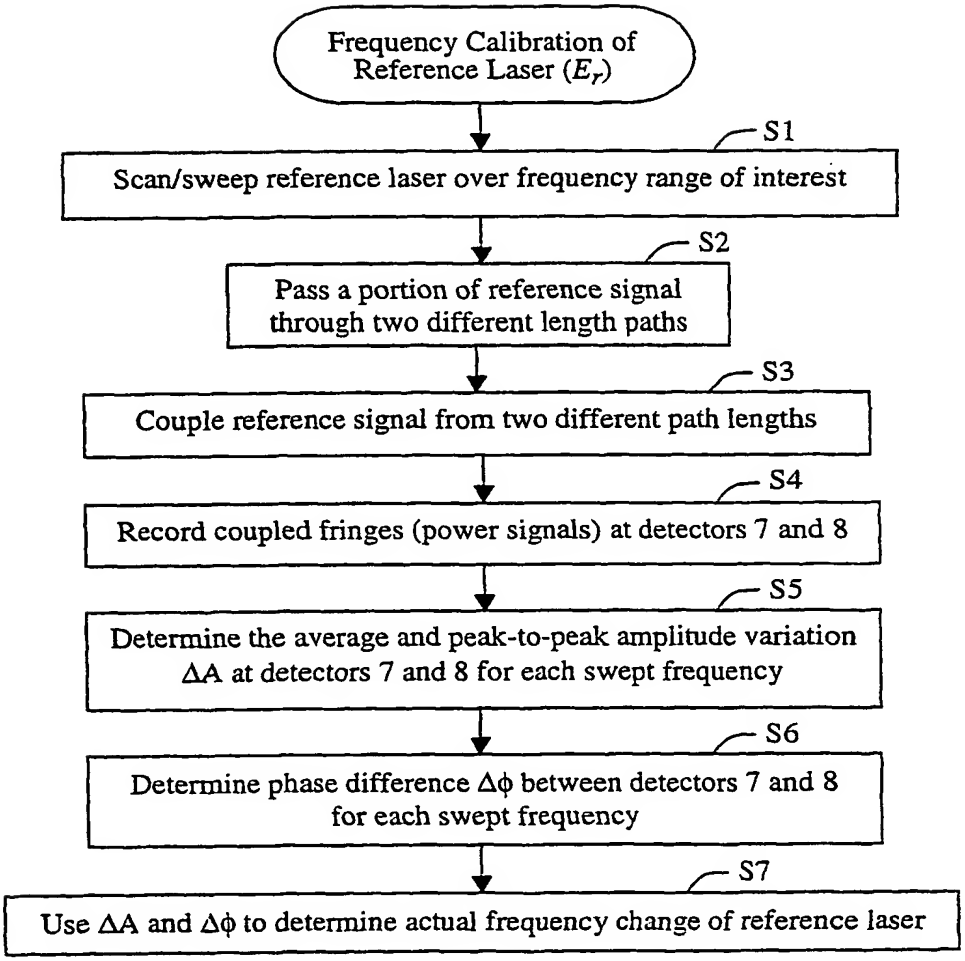

Frequency Calibration of Reference Laser (E_r)
S1
Scan/sweep reference laser over frequency range of interest
S2
Pass a portion of reference signal through two different length paths
S3
Couple reference signal from two different path lengths
S4
Record coupled fringes (power signals) at detectors 7 and 8
S5
Determine the average and peak-to-peak amplitude variation ΔA at detectors 7 and 8 for each swept frequency
S6
Determine phase difference Δϕ between detectors 7 and 8 for each swept frequency
S7
Use ΔA and Δϕ to determine actual frequency change of reference laser

Fig. 15

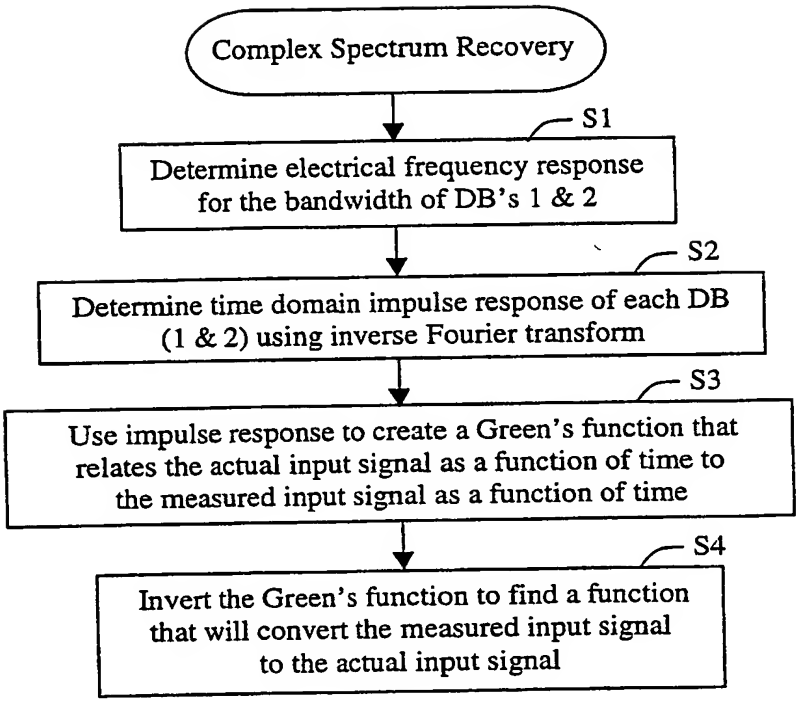

Complex Spectrum Recovery
S1
Determine electrical frequency response for the bandwidth of DB's 1 & 2
S2
Determine time domain impulse response of each DB (1 & 2) using inverse Fourier transform
S3
Use impulse response to create a Green's function that relates the actual input signal as a function of time to the measured input signal as a function of time
S4
Invert the Green's function to find a function that will convert the measured input signal to the actual input signal

Fig. 16